## SECTION 6
## FINDINGS AND RECOMMENDATIONS

### FINDINGS

#### Methods of Measurement

1. Because emission limits and methods of measuring radio emission characteristics are most meaningful when linked to the characteristics of receivers operating or planned to operate in the environment, microwave oven emission limits and methods of measurement must take into consideration the evolution of radio systems above 1 GHz toward digital technologies, often using receiver bandwidths of 1 MHz or more.

2. Measurements based on techniques producing average values are not appropriate for evaluating a radio emitter's impact on broadband receivers.

3. The usefulness of emission standards, such as the FCC's Part 18, based on averaging measurement techniques will decrease as the radio environment continues to shift toward digital systems.

4. Averaging of the measured signal, particularly through the video averaging approach recommended unofficially by the FCC for spectrum analyzer-based measurements, makes it difficult to show the variation between microwave oven emission characteristics, while peak measurements show significant differences in the emission levels from one microwave oven to another.

5. Positive peak detection in a wide measurement bandwidth is useful for recording impulsive, broadband emission types, and therefore might be a more effective method of measurement than an average or quasi-peak based procedure for assessing the interference potential from microwave ovens.

6. The authorization of several different measurement procedures (MP-5, unofficial spectrum analyzer techniques, or others) decreases the likelihood of consistent Part 18 compliance testing results unless each procedure is carefully tested to demonstrate that it produces a result equal to the primary or recommended procedure.

7. Spectrum analyzers are readily available and commonly used for measurements above 1 GHz.

8. Though it is impossible to characterize the emissions of microwave ovens under all of the operating conditions found in common use, a single set of test parameters (possibly with the exception of a single measurement bandwidth) provides an adequate reflection of oven characteristics for standards setting. The parameters that were found to be useful in the NTIA testing procedures are given in the recommendations below.

**Microwave Oven Spectral Emission Characteristics**

9. Each oven has a unique emission spectrum. The fundamental frequency, nominally 2450 MHz, drifts. The rate and extent of the drift, and the dominant operating frequency vary from oven to oven.

10. The results of oven measurements are presented in Sections 4 and 5 as well as in Appendices B, C, and D. The mean EIRP for all ovens (over the bands listed) measured with peak detector was:

| | |
|---|---|
| 2300-2400 MHz | 74 dBpW |
| 2400-2500 MHz | 95 dBpW |
| 2500-2600 MHz | 65 dBpW |

The range of mean EIRP for all ovens (over the bands listed) measured with a peak detector was:

| | |
|---|---|
| 2300-2400 MHz | 61 - 94 dBpW |
| 2400-2500 MHz | 83 - 111 dBpW |
| 2500-2600 MHz | 48 - 80 dBpW |

The range of maximum EIRP for all ovens (over the bands listed) measured with a peak detector was:

| | |
|---|---|
| 2300-2400 MHz | 67 - 105 dBpW |
| 2400-2500 MHz | 106 - 123 dBpW |
| 2500-2600 MHz | 55 - 93 dBpW |

11. The amplitude and probability of occurrence of microwave oven pulses generally decrease as the frequency of separation from 2450 MHz increases. The ovens produce receiver responses of a pulse-like (pulsewidth approximately 7-8 ms) nature near the oven operating frequency, becoming increasingly impulsive (pulsewidth approximately the inverse of receiver bandwidth) as the frequency separation from the oven operating frequency increases.

12. The maximum EIRP at the harmonics measured with a peak detector, averaged for the five ovens selected for harmonic testing, was:

| | |
|---|---|
| fundamental | 111 dBpW |
| 2nd harmonic | 65 dBpW |
| 3rd harmonic | 55 dBpW |
| 4th harmonic | 58 dBpW |
| 5th harmonic | 55 dBpW |
| 6th harmonic | 51 dBpW |
| 7th harmonic | 52 dBpW |

**Microwave Oven Designs Which Minimize Emissions in the Bands Adjacent to 2400-2500 MHz**

13. Manufacturers of microwave ovens can reduce the level of emissions in the bands adjacent to the 2400-2500 MHz band, without increased costs, by selecting magnetron tube types already available that emit lower levels in these frequency ranges.[31/]

## RECOMMENDATIONS

1. The FCC should review the method of measurement and consequently the emission limit that it applies to microwave ovens, and should revise these aspects of Part 18 as necessary to ensure they are appropriate and adequate to protect of radio services present or envisioned for the environment.[32/] Due to the lifespan of microwave ovens, a review must consider the requirements of radio systems to be envisioned to be operating in 10 years or beyond.[33/] In determining the specifics of its measurement procedures, the FCC should link the measurement procedures to the types of receivers to be protected.

2. The FCC should consider requiring peak measurements for microwave ovens, possibly including measurements in a variety of bandwidths, but as a minimum, should abandon the 3 Hz video bandwidth approach.

3. Measurement procedures should be based on readily available measurement equipment such as spectrum analyzers. The procedures should be sufficiently detailed to ensure repeatable results.

4. Measurement procedures should include a single set of test parameters for microwave oven measurements (multiple measurement bandwidths may possibly be needed). The following parameters were found to be useful within the NTIA tests:

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31/ NTIA recognizes that the emission characteristics in the 2300-2400 MHz and 2500-2600 MHz frequency ranges will probably not be the sole determining factor in the selection of a magnetron.

32/ NTIA has in no way attempted here to evaluate the effectiveness of the Part 18 standard to date. In fact with respect to microwave ovens, the limits above 1 GHz based on a narrowband averaging technique cannot be meaningfully assessed with respect to protection of digital systems.

33/ As indicated in Section 1 of this report, NTIA plans to conduct two additional tasks within this effort. The third part will look at future receiver requirements.

| | |
|---|---|
| Oven Load | 1 liter of water |
| Antenna Polarization | Both horizontal and vertical polarization should be authorized |
| Oven Orientation | Measurement antenna should be aimed at the oven door |
| Antenna Height | Antenna should be set at the height of the center of the oven |
| Oven Temperature | Oven should be warmed-up by operation for a few minutes |

5. Considering the demand for radio frequencies, manufacturers of microwave ovens should place great significance on magnetron emission characteristics outside the bands the 2400-2500 MHz band when selecting a magnetron tube.

## REFERENCES


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